VOL. VI, PP. 137-148, PLS. 7, 8 JUNE 22, 1894

THE

NATIONAL GEOGRAPHIC MAGAZINE

THE BATTLE OF THE FOREST

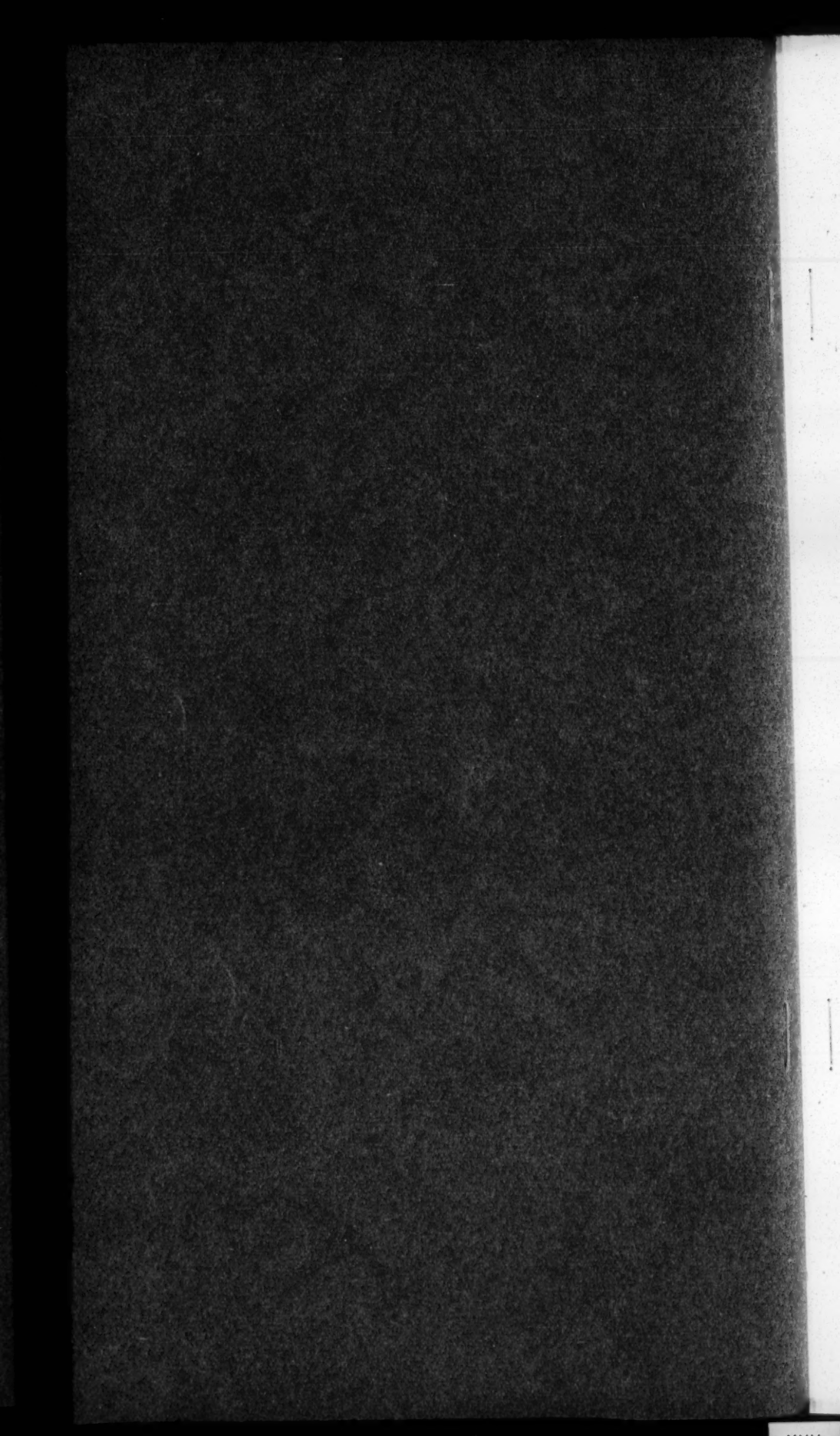
B. E. FERNOW

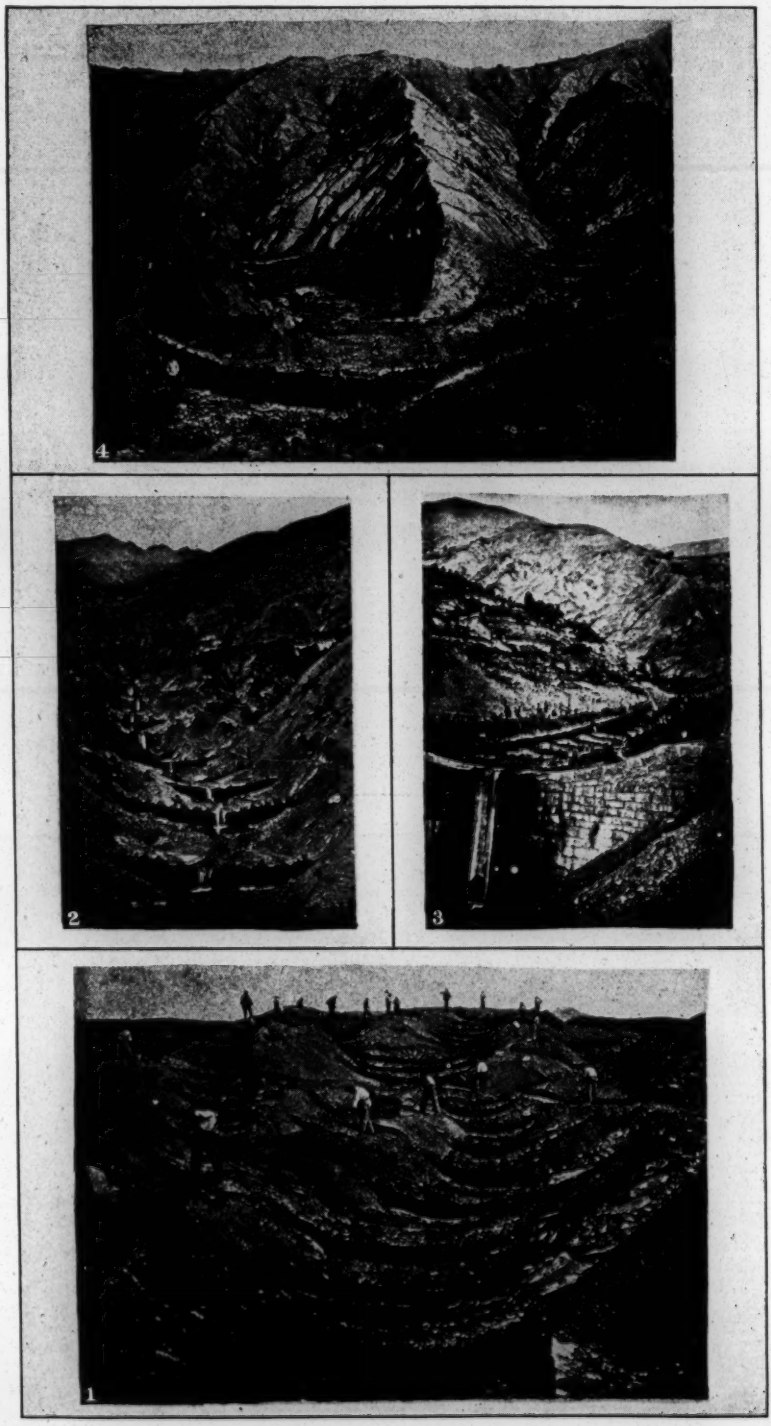
WASHINGTON

PUBLISHED BY THE NATIONAL GEOGRAPHIC SOCIETY

REPRINT

Price 25 cents.





DROWNING THE TORRENT.

1. Wattle-work at summit.
2. Sprouted wattle dam.
3. A masonry dam.
4. Reforestation of denuded mountain side.

VOL. VI, PP. 127-148, PLS. 7, 8 JUNE 22, 1894

THE

NATIONAL GEOGRAPHIC MAGAZINE

THE BATTLE OF THE FOREST

BY

B. E. FERNOW

(*Presented before the Society December 15, 1893*)

The earth is a potential forest. Given time, freedom from geologic revolutions and from interference by man, and tree-growth must finally dominate everywhere, with few excepted localities.

Its perennial nature and its elevation in height above all other forms of vegetation, together with its remarkable recuperative powers, assure to the arborescent flora this final victory over its competitors.

So impressed was Dr Asa Gray with the persistence of individual tree life that he questioned whether a tree need ever die: "For the tree [unlike the animal] is gradually developed by the successive addition of new parts. It annually renews not only its buds and leaves, but its wood and its roots; everything, indeed, that is concerned in its life and growth. Thus, like the fabled Æson, being restored from the decrepitude of age to the bloom of early youth, the most recent branchlets being placed by means of the latest layer of wood in favorable communication with the newly formed roots and these extending at a corresponding rate into fresh soil, why has not the tree all the

conditions of existence in the thousandth that is possessed in the hundredth or the tenth year of its age?

"The old and central part of the trunk may, indeed, decay, but this is of little moment, so long as new layers are regularly formed at the circumference. The tree survives, and it is difficult to show that it is liable to death from old age in any proper sense of the term."*

However this may be, we know trees succumb to external causes. Nevertheless they are perennial enough to outlive aught else, "To be the oldest inhabitants of the globe, to be more ancient than any human monument, as exhibiting in some of its survivors a living antiquity compared with which the moulder-ing relics of the earliest Egyptian civilization, the pyramids themselves, are but structures of yesterday." The dragon trees, so called, found on the island of Tenerife, off the African coast, are believed to be many thousand years old. The largest is only 15 feet in diameter and 75 feet high. Our sequoias are more rapid growers and attain in 3,000 to 4,000 years, which may be the highest age of living ones, more than double these dimensions.

While this persistence of life is one of the attributes which in the battle for life must count of immeasurable advantage, the other characteristic of arboreal development, its elevation in height above everything living, is no less an advantage over all competitors for light, the source of all life. Can there be any doubt that in this competition size must ultimately triumph and the undersized go to the wall?

Endowed with these weapons of defensive and offensive warfare, forest-growth, through all geologic ages during which the earth supported life, has endeavored and no doubt to a degree succeeded in gaining possession of the earth's surface.

As terra firma increased emerging in islands above the ocean, so increased the area of the forest, changing in composition to correspond with the change of physical and climatic conditions.

As early as the Devonian age, when but a small part of our continent was formed, the mud flats and sand reefs, ever increasing by new accumulations under the action of the waves and currents of the ocean, were changed from a bare and lifeless world above tidelevel to one of forest-clad hills and dales.

---

*Longevity of Trees: "Scientific papers of Asa Gray" (selected by Chas. Sargent), vol. 2, 1889, p. 71.

Not only were such quaint forms as the tree rushes or *Calamites*, *Lepidodendra* and *Sigillaria* present, but the prototype of our pine, the *Dadoxylon*, had made its appearance.

The same class of flowerless plants known as vascular cryptogams, with the colossal tree ferns added, became more numerous and luxuriant in the Carboniferous age, as well as the flowering *Sigillaria* and coniferous *Dadoxylon*. This vegetation probably spread over all the dry land, but the thick deposits of vegetable remains accumulating in the marshy places under dense jungle growth and in shallow lakes with floating islands, were finally in the course of geologic revolutions, turned into the great coal fields.

In those and subsequent geologic times some of the floral types vanished altogether and new ones originated, so that at the end of Mesozoic times a considerable change in the landscape had taken place.

In addition to coniferous trees, the palms appeared, and also the first of angiosperms, such as the oak, dogwood, beech, poplar, willow, sassafras and tulip tree. Species increased in numbers, adapted to all sorts of conditions; the forest in a most varied and luxuriant form climbed the mountain sides to the very crests, and covered the land to the very poles with a flora of tropical and semi-tropical species.

Then came the leveling processes and other changes of post-Tertiary or Quaternary times; the glaciation of lands in northern latitudes, with the consequent changes of climate, which brought about corresponding changes in the ranks of the forest, killing out many of the species around the north pole. Only the hardier races survived, and these were driven southward in a veritable rout.

When these boreal times subsided in a degree, the advance of the forest was as sure as before, but the battle order was somewhat changed to suit the new conditions of soil and climate. Only the hardiest tribes could regain the northernmost posts, and these found their former places of occupancy changed by fluvial and lacustrine formations and the drifts borne and deposited by the ice-sheets, while some by their constitution were entirely unfitted from engaging in a northern campaign or found insurmountable barriers in the refrigerated east-west elevations of Europe and western Asia.

In addition, there had come new troubles from volcanic erup-

tions, which continually wrested the reconquered ground from the persistent advance guards of the arboreal army, annihilating them again and again.

Finally, when the more settled geologic and climatic conditions of the present era arrived and the sun arose over a world ready for human habitation, man found what we are pleased to call the virgin forest—a product of long continued evolutionary changes—occupying most, if not all the dry land, and ever intent upon extending its realm.

This prehistoric review of the battle of the forest cannot be left without giving some historic evidences of its truth.

Not only have paleobotanists unearthed the remnants of the circumpolar flora, which give evidence that it resembled that of present tropic and semi-tropic composition, but they have also shown that sequoias, magnolias, liquidambars and hickories existed in Europe and on our own continent in regions where they are now extinct. We have also evidences of the repeated successes and reverses of the forest in its attempts to establish itself through long geologic transformations.

One of the most interesting evidences of these vicissitudes in the battle of the forest is represented in a section of Amethyst mountain in Yellowstone National Park, exhibiting the remains of fifteen forest-growths, one above the other, buried in the lava. Again and again the forest subdued the inhospitable excoriations; again and again it had to yield to superior force.

Among these petrified witnesses of former forest glory, magnolia, oak, tulip tree, sassafras, linden and ash have been identified, accompanying the sequoia in regions where now only the hardiest conifer growths of pines and spruces find a congenial climate.

As the forest formed and spread thus during the course of ages, so does it form and spread today, unless man, driven by the increasing needs of existence, checks its progress and reduces its area by the cultivation of the soil. This natural extension of the forest cover or afforestation takes place readily wherever soil and climate is favorable, but it is accomplished just as surely, though infinitely slower, in unfavorable situations. On the naked rock, the coarse detritus and gravel beds, on the purely siliceous sand deposits of river and ocean, or in the hot dry plains, the preliminary pioneer work of the lower vegetation is required. Algæ, lichens, mosses, grasses, herbs and shrubs must

precede to cultivate the naked rock, to mellow the rough gravel beds, to make the soil, to increase the soil moisture by shading the ground and gradually render it fit for the abode of the forest monarch. The army of soil-makers and soil-breakers, the pioneers, as it were, of the forest, are a hardy race, making less demands for their support than those that follow. They come from different tribes, according to the soil conditions in which they have to battle. As soon as they have established themselves they begin their cultivatory activity, which consists in withdrawing from the rock or soil and from the air the nutritive elements, returning them to the soil when they die and decay, in a form much more suitable for the support of the higher plants. The nutritive elements and the physical properties of the soil are improved and augmented by the repeated growth and decay of these pioneers, in that the soil is deepened and made mellow and its capacity for moisture increased. The waters charged with carbonic acid derived from the decay of the vegetal humus hasten the decomposition of the underlying rock, and the fertile soil layers increase until more fastidious plants can subsist. The humblest workers, algæ, lichens, cacti and mosses, are followed by sedges, dry grasses, herbs and shrubs, or in the drier climates by agaves and yuccas. Then come the succulent grasses and herbs, gradually covering the soil with a meadow or prairie, the shrubs become more numerous, by degrees closing up, shading the ground and overshadowing the grasses, and finally the time is ripe for the arborescent flora. Nor does then the forest appear at once in its fullness and variety of form. Single trees, stragglers or skirmishers in small numbers, and shrub-like and stunted forms first arrive, gradually increasing in number and improving in form. These by their shade and by the litter formed from the fall and decay of their foliage improve the soil for their betters to follow.

The aspen (*Populus tremuloides*) is one of these forerunners, which, thanks to its prolific production of light feathery seed, is readily wafted by the winds over hundreds of miles, readily germinates and rapidly grows under exposure to full sunlight, and even now in the Rocky mountains and elsewhere quickly takes possession of the areas which man has ruthlessly destroyed by fire. This humble and ubiquitous but otherwise almost useless tree is nature's restorative, covering the sores and scalds of the burnt mountain side, the balm poured upon grievous wounds.

Though short-lived, with its light summer foliage turning into brilliant golden autumn hues, it gives grateful shade and preserves from the thirsty sun and wind some moisture, so that the better kinds may thrive and take its place when it has fulfilled its mission.

One of the shrubs or half trees which first take possession of the soil in the western mountain country is the socalled mountain mahogany (*Cercocarpus ledifolius*) covering the bared slopes after the fire has killed the old timber.

In other regions, as on the prairies of Iowa and Illinois, hazel bushes; or in the mountains of Pennsylvania and the Alleghenies in general, ericaceous shrubs like the laurel and rhododendrons or hawthorn, viburnum and wild cherry are the first comers, while along water-courses alders and willows crowd even the water into narrower channels, catching the soil which is washed from the hillsides and increasing the land area.

One of the most interesting soil-makers, wresting new territory from the ocean itself, is the mangrove along the coast of Florida. Not only does it reach out with its aerial roots entangling in their meshes whatever litter may float about and thus gradually building up the shore, but it pitches even its young brood into the advance of the battle, to wrestle with the waves and gain a foothold as best it may.

Not less interesting in this respect is that denizen of the southern swamp, the bald cypress with its curious root excrescences known as cypress knees, which, whatever their physiologic significance, are most helpful in expediting change of water into land sufficiently dry to be capable of supporting the more fastidious species in regard to moisture conditions.

In passing, the remarkable adaptation to diverse conditions of some of the tree species should be noticed, as it gives them significance as geographic factors. The trees of the swamp, or at least many of them, seem to indicate their independence of moisture conditions by the range of climate and soil in which they are found. In fact, they grow in the swamp, not because that is their most suitable locality, but because they can do so to the exclusion of other competitors. The bald cypress itself will grow in the dry soil and arid atmosphere of Texas and Mexico; the oak which associate with it in the swamp will occupy almost any soil and site; the sweet gum or liquidambar is found in similar places of habitat. The juniper or red cedar,

which is a large tree in the swamps of Florida, covers also the driest ridges of the eastern Rocky mountains, with a gnarly growth and hard texture, supplying the most lasting poles and posts. This latter species is also noticeable as having the widest distribution of all American forest trees. In fact, few trees seem so indifferent to climatic and soil conditions. From semi-tropical Florida to the cold shores of New Brunswick, and from the humid Atlantic coast it crosses the continent and the snow-covered Rockies to British Columbia and Washington.* It associates as well with the oak, hickory and magnolia in the rich river bottoms, or with the cypress, ash and tupelo in the swamps, as with the pine on the hot sands and barren mountain sides. Thanks to the taste of the birds for its berries, it finds ready dissemination within this wide field, forming with the equally frugal aspen and cottonwood the very foremost advance guard of the forest.

On the dry hot mesas and in the arroyos of the southwestern tier of our states and territories we meet a different set of skirmishers following up the huge cacti and agaves, which together with the tree yuccas, penetrate into the very desert. In these regions the mesquite or algaroba and others of the acacia tribe form the second phalanx, as it were, gradually advancing their lines in spite of adverse conditions. In other regions the pine, satisfied with but scanty favor of soil moisture, and the spruce, able to sustain life in shallow soil, and the fir, in the higher, colder and wetter elevations, sometimes much stunted, form the skirmish line. These improve the soil in its moisture conditions by their shade, and by the foliage and litter falling and decaying they deepen the soil, forming a humus cover. The duff that is found covering the rocky subsoil of the Adirondacks is formed in this way at the rate of about one foot in 500 years. They are soon followed by the birche, maple, elm and ash and in moister situations by the oak—first, that hardy pioneer, the black oak tribe, and then the more fastidious white oak, with whom the slower but persistent hickories, beeches and other shade-enduring species begin to quarrel for the right of occupancy of the ground, until the battle is no longer that of the forest against the elements and lower vegetation, but between the mighty conquerors themselves. This struggle we can see going on in our primeval forests, wind-storms and decay acting as allies now to

* According to some authorities the juniper found beyond the Rocky mountains does not include this particular species, *Juniperus virginiana*.

one, now to the other side, and thus changing the balance of power again and again.

In this struggle for supremacy between the different arborescent species the competition is less for the soil than for the light, the most important factor of life, especially for tree-growth. It is under the influence of light that foliage develops and that leaves exercise their functions and feed the tree by assimilating the carbon of the air and transpiring the water from the soil. The more foliage and the more light a tree has at its disposal, the more vigorously it will grow and spread itself.

Now the spreading oak or beech of the open field finds close neighbors in the forest, and is narrowed in from all sides and forced to lengthen its shaft, to elevate its crown, to reach up for light, if it would escape being overshadowed, repressed and perhaps finally killed by more powerful densely foliaged competitors.

The various species are differently endowed as regards the amount of light which they need for their existence. Go into the dense forest and see what kinds of trees are vegetating in the dense shade of the older trees, and then go into an opening recently made, an abandoned field or other place, where the full benefit of light is to be had by all alike, and one will find a different set altogether occupying the ground and dominating. In the first case there may be found, perhaps, beech and sugar maple or fir and spruce; in the second case aspen, poplar, willow, soft maple, oak or pine, tamarack, etc.

All trees thrive ultimately best in full enjoyment of light. But some, like those first mentioned, can at least subsist and their foliage functionate with a small amount—they are shade-enduring kinds, usually having a dense foliage, many leaves, and each one needs to do but little work—and exert considerable shade when fully developed. Those last named, however, are light-needing kinds, and having less foliage, cannot exist long without a considerable amount of light.

To offset this drawback in the constitution of these latter, nature has endowed them as a rule with the capacity of rapid height growth, to escape their would-be suppressors; but again, what they have gained in the rapidity of development they lose in the length of life. They are mostly short lived species, while the shade enduring are generally slower growers, but persistent and long lived. Some kinds, like most of the oaks, stand be-

tween the two; while exhibiting a remarkable capacity of vegetating in the shade, they are really light-needing species but comparatively slow growers and long lived. One and the same species behaves also somewhat differently under different soil and climatic conditions; for instance, as a rule the light-needing species can endure more shade on moist soils and the shade enduring require more light on drier soils.

In the earliest stages of life the little seedlings of most trees require partial shade and are quite sensitive in regard to light conditions. Some have such a small range of light and shade endurance that, while there may be millions of little seedlings sprouted, they will all perish if some of the mother trees are not removed and more light given; and they will perish equally if the old growth is removed too suddenly and the delicate leaf structure, under the influence of direct sunlight, is made to exercise its functions beyond its capacity.

Left to itself, as the forest grows up and as the individual trees develop, each trying to hold its ground and struggling for light, a natural thinning takes place, some trees lagging behind in growth and being shaded out, until in old age only as many trees remain as can occupy the ground without incommoding each other.

This struggle among the individuals goes on during their entire life. Some few shoot ahead, perhaps because of a stronger constitution or some favorable external cause, and overtower their neighbors. These, lagging behind, fall more and more under the shading influence of their stronger neighbors until entirely suppressed, when they only vegetate until they die. The struggle continues, however, among the dominant class and it never ends. For as Hercules the unconquerable succumbed to the poison that penetrated to his bones, so does the mighty giant of the forest fall a prey to the insidious work of rot and fungus and insects. When its heart is riddled and weakened, first the dry branches crumble and gradually give opportunity for the young aftergrowth of shade-enduring kinds, patiently waiting for light, to strengthen; then break the large limbs and the dry top, and after having weathered the onslaught of the storms for centuries and the guerillas of the fungus tribe for decades, finally the giant falls, with its decaying substance enriching the soil for future generations. Into the breach rush the young epigones, each struggling to supplant its progenitor.

Thus the alterations of forest-growth take place, oak following pine or pine following oak; the poplar, birch and cherry appearing on the sunny burns, or the hickory, beech and maple creeping into the shadier pine growths. While in the eastern forest under natural conditions the rotation of power is accomplished in at least from 300 to 500 years, the old monarchs of the Pacific, towering above all competitors, have held sway 2,000 or more years. In this warfare, with changes in climatic and soil conditions going on at the same time, it may well occur that a whole race may even be exterminated.

I have dwelt thus long upon the formative period of the forest in order to make you realize that the virgin forest is a product of long struggles, extending over centuries, nay, thousands of years. Some of the mightiest representatives of old families, which at one time of prehistoric date were powerful, still survive, but are gradually succumbing to their fate in our era.

The largest of our eastern forest trees, reaching a height of 140 feet and diameters up to 12 feet, the most beautiful and one of the most useful, the tulip tree (*Liriodendron tulipifera*), is a survivor of an early era once widely distributed, but now confined to eastern North America, and doomed to vanish soon from our woods through man's improper partisanship.

Others, like the *Torreya* and *Cupressus*, seem to have succumbed to a natural decadence, if we may judge from their confined limits of distribution. So, too, the colossal sequoias, remnants of an age when things generally were of larger size than now, appear to be near the end of their reign, while the mighty taxodium or bald cypress, the big tree of the east, still seems vigorous and prosperous, being able to live with wet feet without harm to its constitution, weird with the gray tillandsia or Spanish moss.

Having thus scanned through the traditions of unwritten history of the battle of the forest, having seen some of the combatants in the struggle and learned something of their methods of conquering the earth and each other, we may take a look at the condition of things on the North American continent as it presumably was in the beginning of historic times or within our century.

As far as occupancy of the soil by the forest is concerned, we find that the struggle had not yet been determined in its favor

everywhere. While a vast territory on the Atlantic side and a narrower belt on the Pacific coast, connected by a broad belt through the northern latitudes, was almost entirely under its undisputed sway, and while the back-bone of the continent, the crest and slopes of the Rocky mountains, was more or less in its possession, there still remained a vast empire in the interior unconquered.

Of parts of this territory we feel reasonably certain from strong evidences that the forest once occupied them, but has been driven off by aboriginal man, the firebrand taking sides with the grasses, and the buffalo probably being a potent element in preventing reestablishment. In other parts it is questionable whether the lines along the river courses, the straggling trees on the plateaus and slopes, are remnants of a vanquished army or outposts of an advancing one. In some parts, like the dry mesas, plateaus and arroyos of the interior basin, and the desert-like valleys toward the southern frontiers, it may reasonably be doubted whether arborescent flora has more than begun its slow advance from the outskirts of the established territory.

Certain it is that climatic conditions in these forestless regions are most unfavorable to tree-growth, and it may well be questioned whether in some parts the odds are not entirely against the progress of the forest.

Temperature and moisture conditions of air and soil, determine ultimately the character of vegetation, and these are dependent not only on latitude, but largely on configuration of the land, and especially on the direction of moisture-bearing winds with reference to the trend of mountains.

The winds from the Pacific ocean striking against the Coast range are forced by the compression and subsequent cooling to give up much of their moisture on the windward side; a second impact and further condensation of the moisture takes place on the Cascade range and Sierra Nevada. On descending, with consequent expansion, the wind becomes warmer and drier, so that the interior basin, without additional sources of moisture and no additional cause for condensation, is left without much rainfall and with a very low relative humidity, namely, below 50 per cent. The Rocky mountains finally squeeze out whatever moisture remains in the air currents, which arrive proportionally drier on the eastern slope. This dry condition extends over the plains until the moist currents from the gulf of Mexico modify

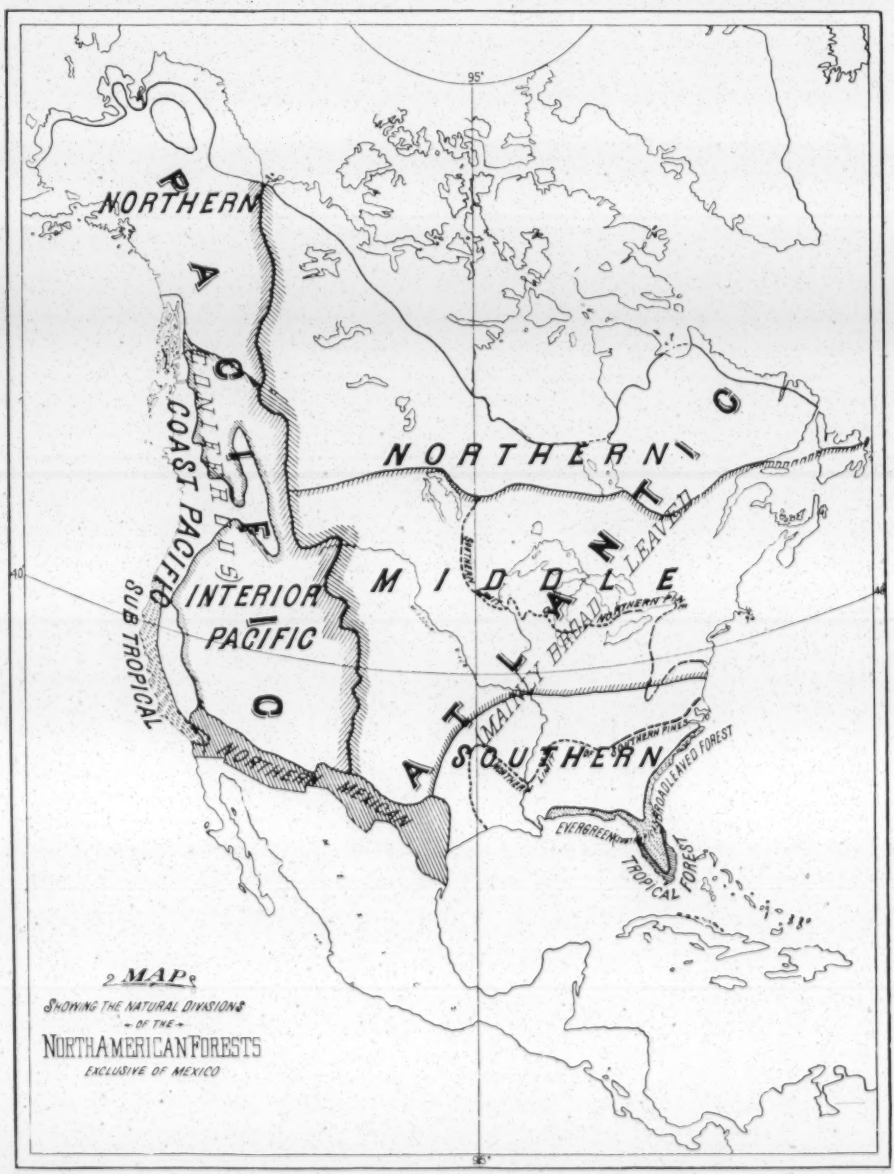
it. Somewhat corresponding, yet not quite, to this distribution of moisture, the western slopes are found to be better wooded than the eastern, and the greater difficulty of establishing a forest cover here must be admitted; yet since the forest has the capacity of creating its own conditions of existence by increasing the most important factor of its life, the relative humidity, the extension of the same may only be a question of time.

Temperature extremes, to be sure, also set a limit to tree-growth, and hence the socalled timber line of high mountains, which changes in altitude according to the latitude.

If, now, we turn our attention from the phyto-topographic consideration of the forest cover to the phyto-geographic and botanical features, we may claim that the North American forest, with 425 or more arborescent species, belonging to 158 genera, many of which are truly endemic, surpasses in variety of useful species and magnificent development, any other forest of the temperate zone, Japan hardly excepted. In addition there are probably nowhere to be seen such extensive fields of distribution of single species.

These two facts are probably explained by the north-and-south direction of the mountain ranges, which permitted a reestablishment after the Ice age of many species farther northward, while in Europe and the main part of Asia the east-west direction of the mountains offered an effectual barrier to such reestablishment, and reduced the number of species and their field of distribution; nor are the climatic differences of different latitudes in North America as great as in Europe, which again predicates greater extent in the fields of distribution north and south. On the other hand, the differences east and west in floral composition of the American forest are greater than if an ocean had separated the two parts instead of the prairie and plains. This fact would militate against our theory that the intermediate forestless region was or would be eventually forested with species from both the established forest regions, if we did not find some species represented in both regions and a junction of the two floras in the very region of the forestless areas.

In the sand hills which traverse Nebraska from east to west there are now found in eastern counties the sand-drowned trunks of the western bull pine, and the same pine belonging to the Pacific flora is found associated with the black walnut of the eastern region along the Niobrara river.



2 MAPS
SHOWING THE NATURAL DIVISIONS
OF THE
NORTH AMERICAN FORESTS
EXCLUSIVE OF MEXICO

We may, however, divide the North American forest, according to its botanical features, into two great forest regions, namely, the Atlantic, which is in the main characterized by broad-leaved trees, and the Pacific, which is made up almost wholly of coniferous species. (See plate 8.)

In the Atlantic forest we can again discern several floral subdivisions, each of which shows special characteristics. The southernmost coast and keys of Florida, although several degrees north of the geographic limit of the tropics, present a truly tropical forest, rich in species of the West Indian flora, which here finds its most northern extension. There is no good reason for calling this outpost *semi*-tropical, as is done on Sargent's map. With the mahogany, the mastic, the royal palm, the mangrove, the sea grape and some sixty more West Indian species represented, it is *tropical* in all but it geographic position. That the northern flora joins the tropic forest here, and thus brings together on this insignificant spot some hundred species, nearly one-quarter of all the species found in the Atlantic forest, does not detract from its tropical character.

On the other hand, the forest north of this region may be called subtropical, for here the live and water oak, the magnolia, the bay tree and holly and many other broad-leaved trees are mixed with the sabal and dwarf palmetto. As they retain their green foliage throughout the winter, this region is truly semi-tropical in character, and under the influence of the Gulf stream, extends in a narrow belt some 20 or 25 miles in width along the coast as far north as North Carolina.

While this evergreen, broad-leaved forest is more or less confined to the rich hummocks and moister situations, the poor sandy soils of this as well as of the more northern region are occupied by pines; and as those, especially the long-leaf pine, are celebrated all over the world and give the great mercantile significance to these forests, this region may well be called the great southern pine belt. North of the evergreen subtropic forest stretches the vast deciduous-leaved forest of the Atlantic, nowhere equaled in the temperate regions of the world in extent and perfection of form, and hardly in the number of species. This designation applies to the entire area up to the northern forest belt, for the region segregated on the census map as the northern pine belt is still in the main the dominion of the deciduous-leaved forest. On certain areas pines and spruces

are intermixed, and on certain soils, especially gravelly drifts and dry sand plains, as on the pine barrens of northern Michigan, they congregate even to the exclusion of other species. Instead, we can divide this deciduous-leaved forest by a line running somewhere below the fortieth degree of latitude, where with the northern limits of the southern magnolias and other species we may locate in general the northern limit of the southern forest flora. Northward from here, in what may be called the "middle Atlantic forest," the deciduous species rapidly decrease and the coniferous growth predominates until we arrive at the broad belt of the northern forest, which, crossing from the Atlantic to the Pacific and composed of only eight hardy species, takes its stand against the frigid breath and icy hands of Boreas.

Abounding in streams, lakes and swampy areas, the low divides of this region are occupied by an open stunted forest of black and white spruce, while the bottoms are held by the balsam fir, larch or tamarack, poplar, dwarf birch and willow. The white spruce, paper or canoe birch, balsam, poplar and aspen stretch their lines from the Atlantic to the Pacific over the whole continent.

On the Pacific side the subdivisions are rather ranked from west to east. While the northern forest battles against the cold blasts from icy fields, the front of the Pacific interior forest is wrestling with the dry atmosphere of the plains and interior basin. Here on the driest parts, where the sage brush finds its home, the ponderous bull pine is the foremost fighter, and where even this hardy tree cannot succeed in the interior basin several species of red cedar hold the fort, in company with the nut pine, covering with an open growth the mesas and lower mountain slopes. Small and stunted, although of immense age, these valiant outposts show the marks of severe struggles for existence.

On the higher and therefore moister and cooler elevations and in the narrow canyons, where evaporation is diminished and the soil is fresher, the somber Douglas, Engelmann and blue spruce and the silver-foliaged white fir join the pines or take their place.

With few exceptions the same species, only of better development, are found in the second parallel, which occupies the western slopes of the Sierra Nevada. Additional forces here strengthen the ranks, the great sugar pine, two noble firs, a mighty larch, hemlocks and cedars vie with their leaders, the

big sequoias, in showing of what metal they are made. The third parallel, occupied by the forest of the Coast Range, the most wonderfully developed, although far from being the most varied of this continent, is commanded by the redwood, with the tide-land spruce, hemlock and gigantic arborvitæ joining the ranks.

Broad-leaved trees are not absent, but so little developed in comparison with the mighty conifers that they play no conspicuous part except along the river bottoms, where the maple, cotton, wood, ash and alder thrive, and in the narrow interior valleys, where an open growth of oak is found. Toward the south and on the lower levels these broad-leaved trees again become evergreen, as on the Atlantic side, but of different tribes, and form a subtropic flora.

Along the coast we find several species of true cypress, including the well known although rare Monterey cypress which clings to the gigantic rocks and braves the briny ocean winds, and with its branches twisted landward. Finally, flanking the battle order of the Pacific forest, we find another section of the army, composed of the northern extension of the Mexican flora-mingled with which are species from the Pacific forest on the west and from the Atlantic on the east.

The mesquite and some acacias, the tree yuccas and the giant or tree cactus are perhaps the most characteristic and remarkable species of the deserts of this region, while the high mountains support dense forests of firs and pines.

So far we have considered the forest only from the geographic and botanical point of view, and have watched the history of its struggle for existence against the elements and against the lower vegetation and other forces of nature. A new chapter of its life history, which we shall have time only to scan very briefly, began when man came upon the scene and the economic point of view had to be considered.

For ages man has taken sides against the forest. Not only has he contested for the occupancy of the soil, in order to cultivate his crops or to make the meadow for his cattle—a most legitimate and justifiable proceeding,—and not only has he utilized the vast stores of wood accumulated through centuries, for the ten thousand uses to which this material can be applied, and in the application of which he exhibits his superior intelligence, but he

has also shown a woeful lack of intelligence in the willful or careless destruction of the forest without justifiable cause, and by just so much curtailing the bountiful stores provided by nature for him and his progeny. Not only has he, like a spendthrift, wasted his stores of useful material, but more—he has wasted the work of nature through thousands of years by the foolish destruction of the forest cover, wresting from it the toilsomely achieved victory over the soil. He has destroyed the grasses and even all vestige of vegetation, and has handed over the naked soil to the action of wind and water. As the fertility and agriculture of the plain is dependent upon the regular and equable flow of water from the mountains, such as a forest cover alone can secure, he has by baring the slopes accomplished in many localities utter ruin to himself, and turned them back into inhospitable deserts as they first were before the struggle of the forest had made them inhabitable.

One would hardly believe that certain mountains in France had ever seen a luxuriant forest growth, and could during historic times have been so utterly despoiled of their vegetal cover. Yet axe, fire and cattle have been most successful, and the consequences have been felt not only in the mountains, but in the valleys below. The waters in torrents have brought down the soil and débris, covering out of sight the fertile fields of thousands of toiling farmers. They themselves have brought this ruin upon them on account of their ignorance of the relation of forest cover to their occupation. Now, with infinite hard work and expenditure of energy and money, the slow work of restoring the forest to its possessions has begun. The first work is to take care of the rain waters, and by artificial breaks turn them from rushing torrents over the bare surface into a succession of gentle runs and falls by fascine and stone works. This work must be begun at the very top of the mountains, at the very source of the evil, where the water receives its first momentum in the descent to the valley. The fascines or wattles, laid across each rivulet at more or less frequent distances from each other and fastened down by heavy stones, are made of live willows or other readily sprouting species, which in course of time strike root and become living barriers. The pockets behind these breastworks gradually fill up, and the contour of the mountain side is changed from an even and rapid descent into a series of steps with gentle fall, over which the formerly rushing waters,

gradually and without turbulence, find their way to the valley below. Where the incline is too steep and higher breastworks are necessary, they are made of masonry, sometimes at great expense. At the base of these overflow dams an opening is left for the water to drain through, even after the depression behind the rampart has filled up with débris and soil has washed down from above. Then, when in this way the soil has come to rest, forest planting begins, and gradually the torrent is "drowned in vegetation." Sometimes, where on a steep mountain side the naked rock alone has been left, it becomes necessary to carry in baskets the soil to the trenches hewn in the rock, where the little seedlings may take their first hold, until they are strong enough to fight their own battle and make their own soil, gradually restoring the beneficent conditions which nature had provided before the arrival of man and his senseless, improvident, self-destructive greed. By the irrational destruction of the forest, first for the supply of timber, then through the careless use of fire, by the clearing for unsuitable farm use, by excessive grazing of sheep and goat, the mountain sides themselves are not only devastated and made useless, but fertile farms for 200 miles from the source of the evil are ruined by the deposit of the débris, and the population pauperized and driven from their homes. Many millions of dollars have been and many more will have to be spent before these regions become habitable again. On plate 7 are shown various views of these processes of afforestation as now practiced in France.

That we are working in this country toward the same conditions is too well known to need rehearsal. Go to the shores of lake Michigan or visit the coast of New England, New Jersey, Pennsylvania, down to the Gulf, and you can see the destructive action of the shifting sands set loose by improvident removal of the plant-cover. Go to the Adirondacks, the highlands of Mississippi, or the eastern slopes of the Rocky mountains, and aspects similar to those derived from France will meet your view.

Thus McGree graphically describes the formation of the Mississippi bad lands:*

With the moral revolution of the early sixties came an industrial evolution; the planter was impoverished, his sons were slain, his slaves were liberated, and he was fain either to vacate the plantation or greatly to

* In a paper read before the American Association for the Advancement of Science, at Washington, in 1891 (not printed).

restrict his operations. So the cultivated acres were abandoned by thousands. Then the hills, no longer protected by the forest foliage, no longer bound by the forest roots, no longer guarded by the bark and brush dam of the careful overseer, were attacked by raindrops and rain-born rivulets and gullied and channeled in all directions; each streamlet reached a hundred arms into the hills, each arm grasped with a hundred fingers a hundred shreds of soil, and as each shred was torn away the slope was steepened and the theft of the next storm made easier.

So, storm by storm and year by year, the old fields were invaded by gullies, gorges, ravines and gulches, ever increasing in width and depth until whole hillsides were carved away, until the soil of a thousand years' growth melted into the streams, until the fair acres of ante-bellum days were converted by hundreds into bad lands, desolate and dreary as those of the Dakotas. Over much of the upland the traveler is never out of sight of glaring sand wastes where once were fruitful fields; his way lies sometimes in, sometimes between, gullies and gorges, the "gulfs" of the blacks whose superstitions they arouse, sometimes shadowed by foliage, but oftener exposed to the glare of the sun reflected from barren sands. Here the road winds through a gorge so steep that the sunlight scarcely enters; there it traverses a narrow crest of earth between the chasms, scores of feet deep, in which he might be plunged by a single misstep. When the shower comes he may see the roadway rendered impassable, even obliterated, within a few minutes; always sees the falling waters accumulate as viscid brown or red mud torrents, while the myriad miniature pinnacles and defiles before him are transformed by the beating raindrops and rushing rills so completely, that when the sun shines again he may not recognize the nearer landscape.

This destruction is not confined to a single field or a single region, but extends over much of the upland. While the actual acreage of soil thus destroyed has not been measured, the traveler through the region on horseback daily sees thousands or tens of thousands of formerly fertile acres now barren sands; and it is probably within the truth to estimate that 10 per cent of upland Mississippi has been so far converted into bad lands as to be practically ruined for agriculture under existing commercial conditions, and that the annual loss in real estate exceeds the revenues from all sources; and all this havoc has been wrought within a quarter century. The processes, too, are cumulative; each year's rate of destruction is higher than the last.

The transformation of the fertile hills into sand wastes is not the sole injury. The sandy soil is carried into the valleys to bury the fields, invade the roadways, and convert the formerly rich bottom lands into treacherous quicksands when wet and blistering deserts when dry. Hundreds of thousands of acres have thus been destroyed since the gullying of hills began a quarter of a century ago. Moreover, in much of the uplands the loss is not alone that of the soil, *i. e.*, the humus representing the constructive product of water work and plant work for thousands of years; but the mantle of brown loam, most excellent of soil stuffs, is cut through and carried away by corrasion and sapping, leaving in its stead

the inferior soil stuff of the Lafayette formation. In such cases the destruction is irremediable by human craft—the fine loam once removed can never be restored. The area from which this loam is already gone is appalling, and the rate of loss is increasing in a geometric proportion.

What the farmer has brought upon himself here by excessive clearing, the lumberer, prospector, miner or hunter prepares in the farther west by reckless and purposeless use of fire. Burnt mountain sides, where no living thing can subsist in comfort, cover not acres but hundreds of square miles in the western country. While the first fire only deadens the trees or undermines their constitution, the second or third fire usually is sufficient to kill what remain alive and even to clean up the fallen timber. That these bald spots are not more frequent than they are is only due to the short period of our endeavors in disturbing the balance of nature.

But as our nation prides itself on the rapidity of its development, exercising to the utmost our constructive energies, so do we excel in destructive and wasteful energies and tendencies, and we shall come to grief with our resources much sooner than some of our happy-go-lucky friends would like to make us believe. While these exhibitions of American vandalism are beyond the proprieties of legitimate warfare, there is not much more propriety or intelligence visible in the manner in which we levy tribute from the forest for our legitimate needs. Forests grow to be used, but there is a great difference between intelligent and unintelligent use. Improvidence and ignorance characterize the present methods of using the forest-growth. The value of it is not even known. Of the 425 or more species which are represented in the forests, not more than 40 or 50 at the most are found in the markets. Although, to be sure, many of the species are of but little or of no economic value, the number of the truly useful trees is probably twice or three times as great as that actually used. Ignorance as to the true value of them keeps many from little more than simply a strictly local use or from their most fit employment. The story of the black walnut used for fence rails or firewood is well known. Six years ago the red gum or liquidambar, now a fashionable finishing material, was despised. Ten years ago large hemlock trees were mouldering in the woods after the bark had been taken for tanning purposes because the value of the wood was unknown. Cypress and Douglas spruce cannot yet overcome the prejudice of the market. On the other hand, cot-

tonwood and tulip poplar, not long ago among the despised or only locally used, can hardly now be furnished in sufficient quantities, and the long-leaf pine, which had been bled for turpentine, was considered an inferior material, which, as has lately been shown, is nothing but an unwarranted prejudice.

In a vague empirical way the choice of the useful has been attempted and only lately have we begun to systematically study our forest resources, to determine the qualities and adaptabilities of our timbers, and to find out the conditions under which they produce not only the largest amount but the best quality of timber.

Yet in another direction do the forest users act unintelligently. As we have seen, most of our forest trees are of a social character. With few exceptions, they keep company with other kinds than their own; they appear in mixed forests. Hence, except where certain species as the pines and spruces become gregarious and form unmixed, pure forests, the axe of the lumberer does not as a rule level the entire forest, but he selects the kinds which he wishes to use—he culls the forest. At first sight this would appear rather an advantage for the existence of the forest. So it is from a botanical, geographic or landscape point of view, yet from an economic point it is exactly the reverse—it is disastrous.

This can be readily understood if we recall our story of the battle of the forest monarchs among themselves, the struggle which each species sustains to occupy the ground. Man taking sides in the struggle by culling the best, the most useful, decides the battle for the least deserving, leaving the advantage to the scrubs and inferior tribes; and since these are left to overshadow the ground and to spread their own brood over the open spaces, the culled forest, while still a forest to the casual observer, has lost its economic value not only for the present, but for the future also, for it prevents the reproduction of the better kinds. The intelligent forester also acts as a partisan; he also uses the axe, but to better purpose. Before he utilizes the kinds for which he wishes to perpetuate the forest, he culls the inferior and leaves the superior—*i. e.*, the most useful races; he gives direction and assists the most fit in the struggle for supremacy; he substitutes artificial for natural selection, assuring the protected survival of the most useful; he hastens the decision of the struggle by obviating, if possible, useless expenditure of

energy by timely interference, thereby securing not only a larger total and more valuable product for the present, but a reproduction of only the best kinds for the future.

In the well managed forests of Germany the undeserving species are exterminated and the most useful fostered, just as the agriculturist exterminates the weeds and cultivates the crop. Not only is the forest there confined to those soils and locations which cannot be used to better advantage or which require a forest cover in order to protect the soil against detrimental dis-

FIGURE 1.—*A German spruce Forest under management.*

placement, but it is so managed as to become a more and more valuable resource, a crop of increasing importance, under the management of skilled foresters, of whom, in a late debate on the floor of the Landtag of Prussia, it was said that "While most other productive business has declined, the forest administration has steadily improved and yielded increasing revenues." In figure 1 is shown one of these protected German forests of spruce, as they grow, not planted, but naturally regenerated by skillful management and use of the axe.

The battle of the forest in this country is now fought by man, the unintelligent and greedy carrying on a war of extermination, without the knowledge that their victory may lead eventually to their own destitution; the intelligent and provident trying to defend the forest cover and endeavoring to prevent its removal from such lands as cannot serve a better purpose, and to restrict the use of the balance to such rational harvest of its material, without injurious effects on soil and water conditions, as will insure an ever reproducing crop and a permanent national resource.

While man may *study* the geography of the earth as it exists, here is about the only opportunity for him to *make* geography, to shape the surface conditions of the earth, and even to some extent influence its climatic conditions.

XUM